Localization behavior of electromagnetic wave in three-dimensional pohotonic fractals

S. Kirihara and Y. Miyamoto
Joining and Welding Research Institute, Osaka University
11-1 Mihogaoka Ibaraki, Osaka 567-0047, Japan
M. W. Takeda and K. Honda
Faculty of Science, Shinshu University
3-1-1 Asahi Matsumoto, Nagano 390-8621, Japan
K. Sakoda
Nanomaterials Laboratory, National Institute for Materials Science
3-13 Sakura, Tsukuba, Ibaraki 305-0003, Japan

Three-dimensional photonic fractals with the self-similar pattern of dielectric media can localize strongly electromagnetic waves. We have fabricated various 3D photonic fractals with Menger-sponge structure composed of epoxy with titania-silica particles dispersion using stereolithography of a CAD/CAM system. Menger-sponge structures have the cubic body with the cube size a and square through-holes with the edge sizes of a/3, a/32, a/33,..depending on the stage number. When the cube size is 81mm, the localized frequencies measured by using network analyzer and two horn antennas were 9.5, 10.5, 12.0 and 13.5 GHz for stage 1, 2, 3, and 4, respectively. These localized frequencies showed good agreements with the calculated ones using an empirical equation which we derived to predict the localized wavelength as functions of the cube size, stage number, volumetric mean dielectric constant, and order number of a localized mode. The intensity profiles of electric field measured at the inner and outer air space of Menger sponge fractals with the stage number over 2 confirmed the complete confinement of the wave energy. When the cubic symmetry was broaken by introducing small distorsions or tetragonality, or by filling some square holes with the same media, broadning, splitting, and quenching of localized modes occurred. These interesting localization behaviors of electromagnetic waves in photonic fractals with Menger sponge structures and their modified structures will be reported.